Preventing Hypothermia in Critically Ill Patients during Aeromedical Evacuation

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Background/Significance

- Sparked by experiences during Operation ANACONDA
- Body heat is lost through: radiation, convection, conduction & evaporation
- Hypothermia (< 35° C) causes potentially life-threatening pathophysiologic changes
- Majority literature r/t treatment – goal: halt the fall in core body temperature, and maximize a safe rewarming rate

Background/Significance

- Temperature
  - C-141 mean minimum 49.2 ± 3.1˚F (range 43.7 – 53.6˚F) [1]
  - KC-135 mean minimum 59.3 ± 10.6˚F (range 44.7 – 79.4˚F)
- Airflow
  - C-141 average 0.3 ± 0.1 m/sec. (maximum average airflow was 1.1 ± 0.5 m/sec) [1]

1 – Bridges and colleagues Thermal Stress and the Human Response Onboard

Interventions Eliminated

Intervention	Rationale
Shivering, Exercise	Increase morbidity
Forced Air Warming, Charcoal Heaters	Aircraft fuel vapor hazard
Hot Water Bottles, Hot Soaked Sheets	No method for warming
Piped Suits	Not suited for multi-use
Radiant Heat	Requires too much power
Warm Water Immersion, Human body, Hot food/drink,	Inappropriate for setting

Interventions Selected

Heating pads	✈ Within aircraft power limits ✈ Multi-patient use ✈ Small, lightweight portable ✈ No aircraft safety issues
Warmed blankets (electric)	
Inhalation of heated air	
Warm IV fluids	

Purpose/Aim

To evaluate the efficacy of portable electric warming blankets in preventing hypothermia in an austere military environment.

Research Question

In normothermic subjects with resuscitated hypovolemic shock exposed to six hours of cold exposure (50˚F/10˚C):

- Is there a difference in the change in core body temperature from baseline between Caswarm, Chillbuster® and standard military blankets in subjects allowed to shiver or when shivering thermo-genesis is suppressed?
- Is there a difference in the appearance of shivering between Caswarm, Chillbuster and standard military blankets?

Design

28 pigs (Yorkshire swine, 55-65 kg)

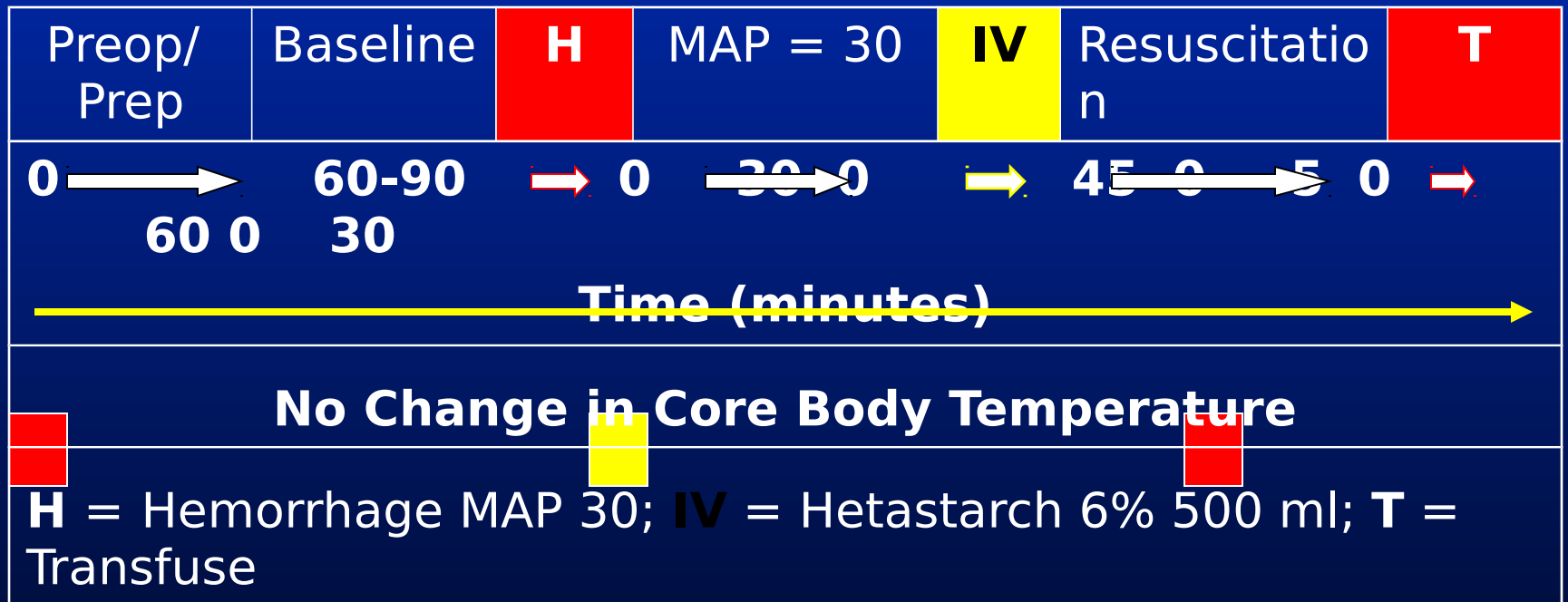
Subjects Allowed to Shiver	
Group 1	Two wool military blankets
Group 2	Caswarm, plus one wool blanket
Group 3	Chillbuster®, plus one wool blanket
Subjects Not Allowed to Shiver	
Group 4	Two wool military blankets
Group 5	Chillbuster®, plus one wool blanket

Preparatory/Baseline

- Anesthesia
- Instrumentation
- Body temperature measurement: pulmonary artery, rectal, skin
- Environmental temperature: Wet-bulb globe thermometer
- Airflow = thermoanemometer

Injury-Resuscitation Model

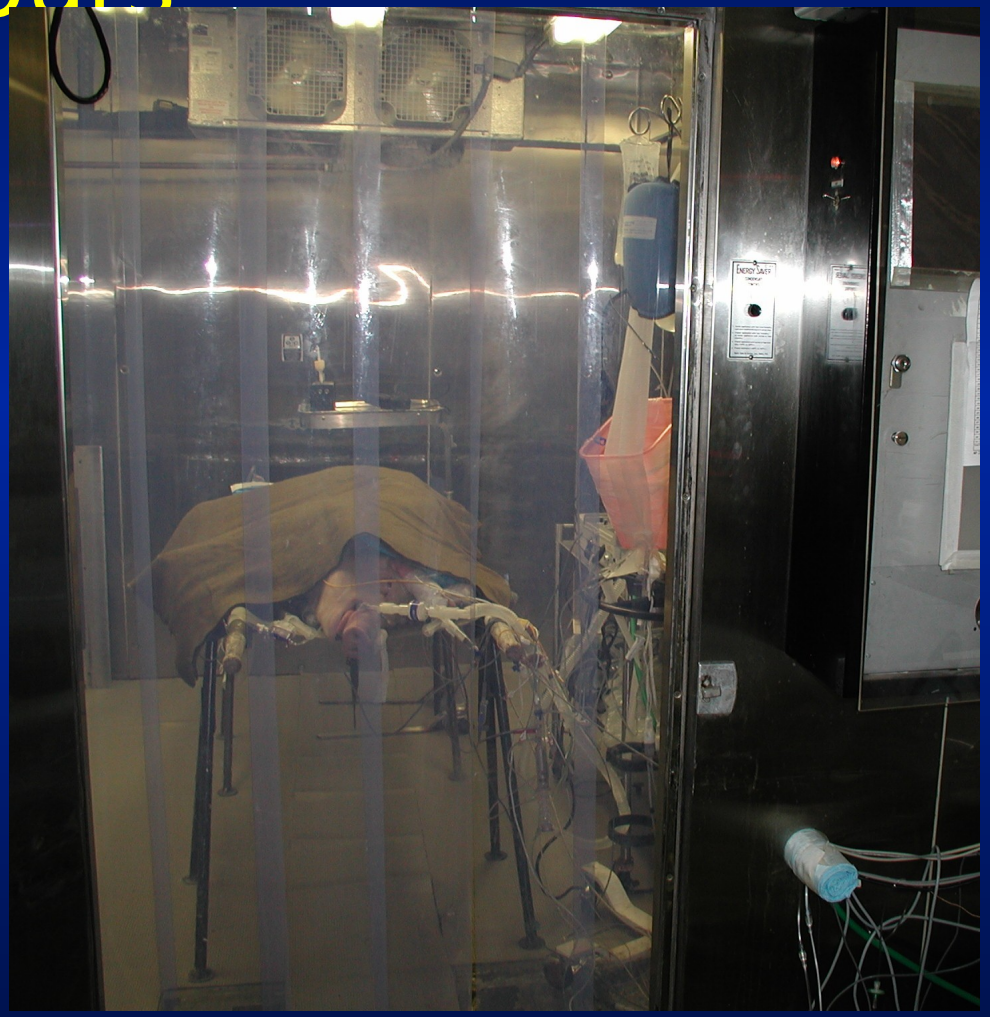
A well-developed hypovolemic shock model was used to mimic injury and resuscitation in a forward deployed environment.



Cold Exposure Phase

- Positioned left side, NATO litter with double folded wool blanket beneath
- Impact 754 transport ventilator w/ HME
- IV anesthesia (propafol, ketamine)
- Neuromuscular blockade (pavulon) – groups 4 & 5

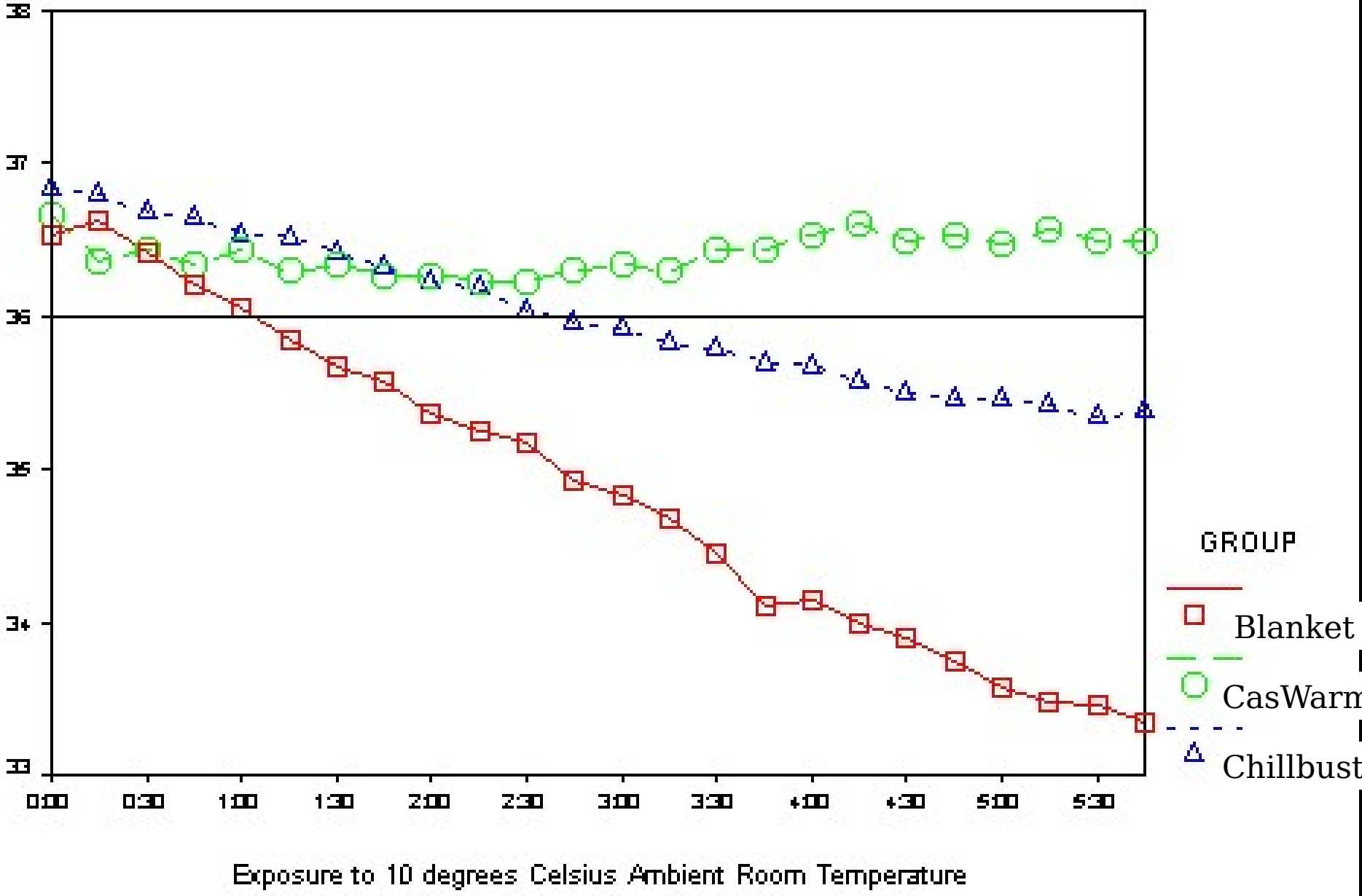
50°F/10°C air temperature - six hours



Temperature Data Analysis
Subjects allowed to shiver
(groups 1 – 3)

- ANOVA
- Data were normalized - change in core body temperature from baseline
- There was a significant difference (p =.02) in the change in temperature between Caswarm (mean -0.9°C/SD=1.9) and Blanket (mean -4.1°C/SD=1.2)

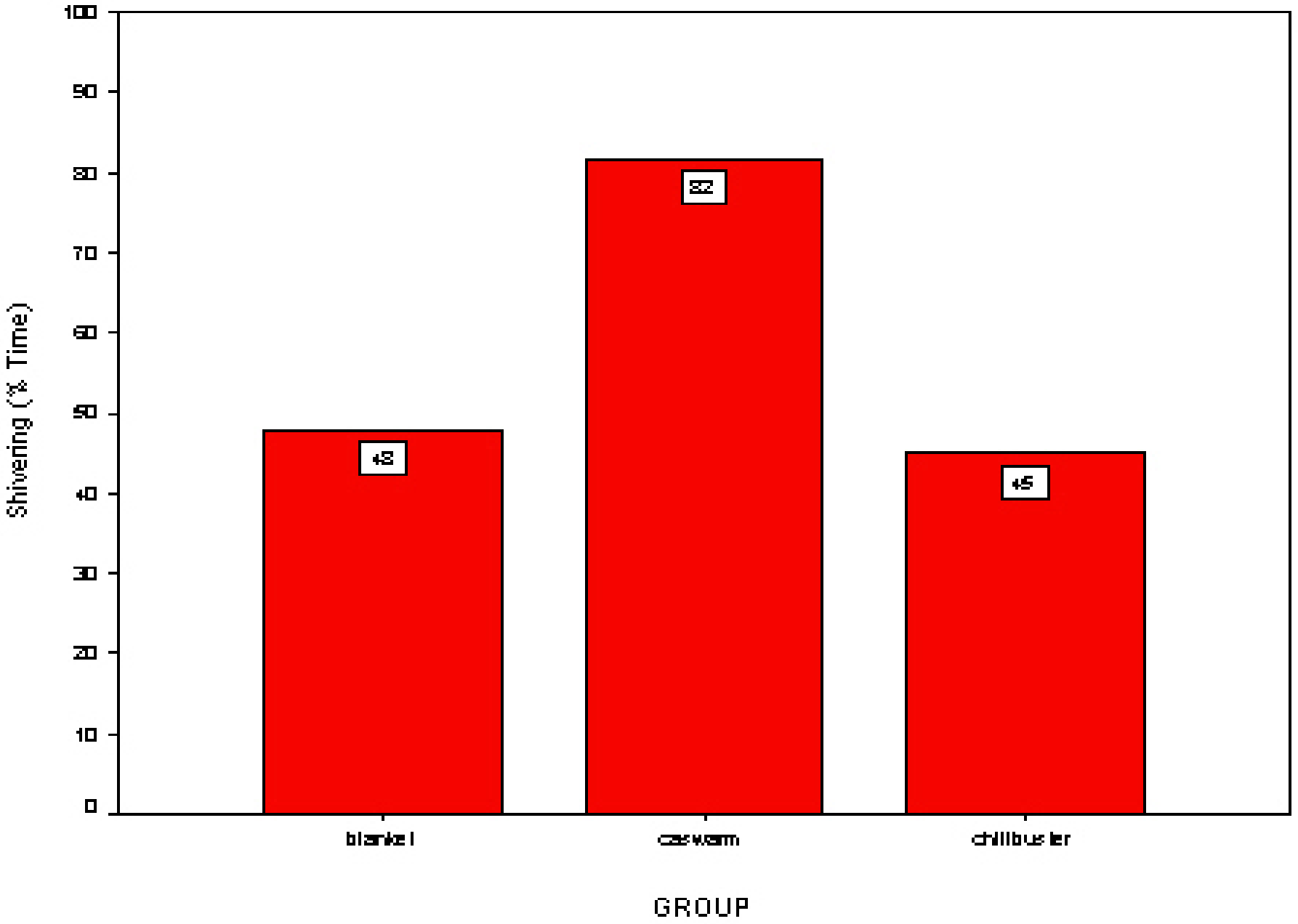
Core Body Temperature Change Over 6 Hours
Groups 1 – 3 (With Shivering)



Shivering Data Analysis
Subjects Allowed to Shiver
(Groups 1 – 3)

- Shivering was expressed as a percentage of the cold exposure time
- There were no differences (p=.06) in the percentage of time shivering among the groups
- All animals shivered at least some of the time during cold exposure

Percentage of Shivering Over 6 hours Cold Exp

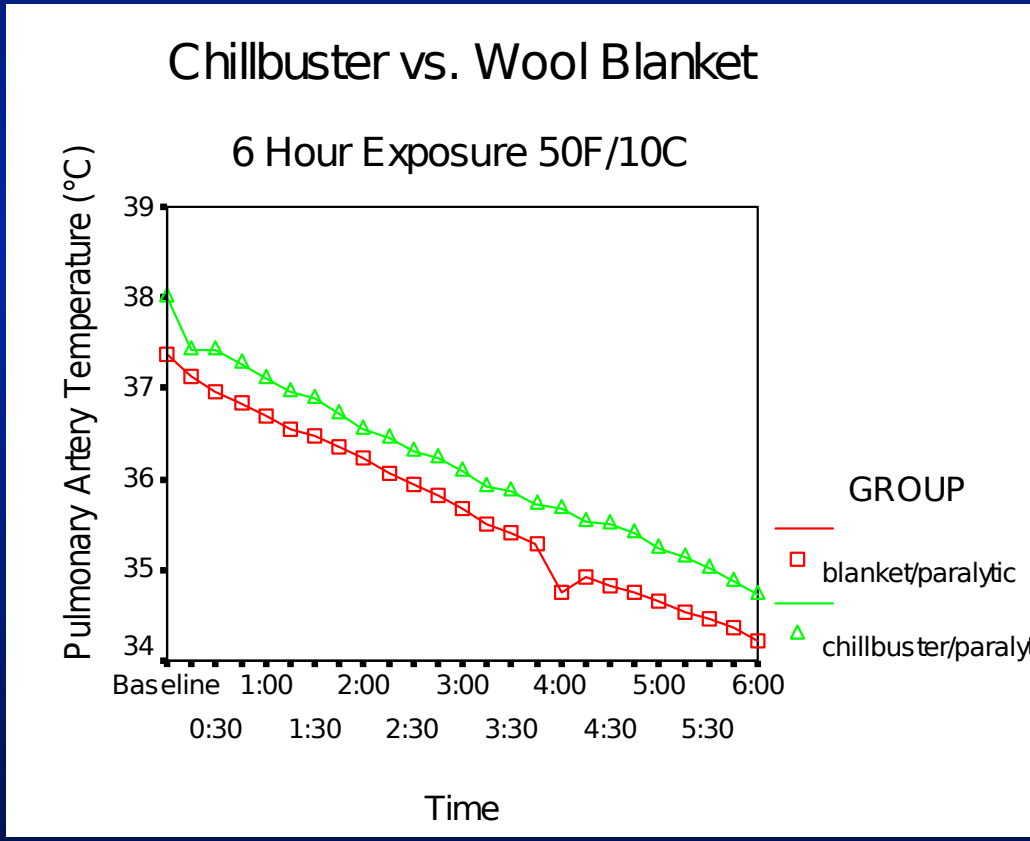


Temperature Data Analysis
Subjects Not Allowed to Shiver
(Groups 4 - 5)

There was no difference (p=.45) in the change in temperature between:

Chillbuster - mean -3.27°C (SD 1.52)

Blanket - mean -3.16°C (SD 1.24)



Conclusions

- The heating blankets evaluated in this study were not effective in preventing heat loss and/or shivering after six hours of cold exposure
- When shivering was suppressed, the Chillbuster was not effective in preventing hypothermia after six hours of cold exposure
- Results from the Chillbuster were not significantly different from the blankets
- The Caswarm was not tested when shivering was suppressed

Implications

- As a single prevention strategy, the warming devices are not effective in preventing hypothermia in this critical care model
- Future research is needed to test combinations of heat production and heat retention strategies ability to prevent hypothermia in a military unique environment
  - Heating blankets + space blankets
  - Airway warming device (HME Booster Plus)
  - IV fluid warmer (Thermal Angel)

Questions